points out that although these naked-eye observations are subject to a more considerable personal error than if they could have been made with any kind of instrument, yet the determination of the position of this phenomenon depends to a great deal on the experience of the observer. The best method he suggests for its location is to estimate the distance of its centre from the nearest fixed star, and then to identify the star by a chart or an equatorial pointing; by this means he can ordinarily determine the centre to within one degree. Any attempt, he says, to locate its position by tracing the outlines among the stars can only lead the observer to very crude results. Prof. Barnard's observations have indicated that the Gegenschein seems subject to periodical changes in the first parts of October and April; but the weather this year did not permit of a corroboration of this statement. The present observations show that this phenomenon has a north latitude as formerly, and that there is still a tendency to lag in longitude; that is, its longitude is not exactly 180° greater than that of the sun. The following summary shows the results for the last fourteen years:—

Dates.	Lat.	Diff. Long. (λ − ⊙)	No. Obs.
	°	°	
1883–1887	+0·4	179·4	16
1888–1891	+1·3	179·4	16
1893	+0·5	179·6	22
1894–1897	+0·4	179·9	11

It may be stated that the difference in longitude for the last four years given above is rather high, owing to the fact that the three observations of 1894 made the difference greater than 180°. Those for 1895 and 1897 gave a value considerably less than 180°.

PERIODIC VARIATIONS OF RAINFALL IN INDIA.

THE meteorology of India during the past five years, 1892-96, has been characterised by the largest and most marked periodic variation of rainfall during the past fifty years at least, and probably for a much longer period. The late Mr. Blanford's monograph on the rainfall of India (page 15) gives a brief statement of the method he adopted for ascertaining the average rainfall of India, year by year, and the normal average. According to this method the mean normal annual rainfall of India is, very approximately, 41 inches. The following gives a comparison of the actual mean rainfall of India with the normal mean for each year from 1875 to 1896, determined by Mr. Blanford's method.

Year.	Mean actual Rainfall.	Variation from normal.	Percentage variation.
	Inches.	Inches.	
1875	43·47	+ 2·38	+ 6
1876	36·60	− 4·49	− 11
1877	36·81	− 4·28	− 10
1878	47·43	+ 6·34	+ 15
1879	42·78	+ 1·69	+ 4
1880	39·53	− 1·56	− 4
1881	41·19	+ 0·10	0
1882	43·73	+ 2·64	+ 6
1883	40·97	− 0·12	0
1884	42·82	+ 1·73	+ 4
1885	42·14	+ 1·05	+ 3
1886	44·11	+ 3·02	+ 7
1887	43·51	+ 2·42	+ 6
1888	39·55	− 1·54	− 4
1889	43·50	+ 2·41	+ 6
1890	41·77	+ 0·68	+ 2
1891	37·55	− 3·54	− 9
1892	46·18	+ 5·09	+ 12
1893	50·16	+ 9·07	+ 22
1894	47·56	+ 6·47	+ 16
1895	38·90	− 2·90	− 7
1896	36·26	− 4·83	− 12

The preceding data indicate that from 1876 to 1891 the annual rainfall of India varied somewhat irregularly and by less than 10 per cent. from the normal with one exception, viz. during the period 1876–78. The meteorological features of this period were very remarkable (*vide* NATURE, vol. xxi., page 477, "On the barometric see-saw between Russia and India in the sun-spot cycle," by H. F. Blanford), the most noteworthy being the drought and famine in Madras in 1876, and the scanty rainfall in North-western India in 1877, which gave rise to considerable suffering. Mr. Blanford subsequently traced the cause of the deficient rainfall in North-western India in 1877 to conditions and actions resulting from excessive snowfall in the Himalayan region during the winter of 1876–77.

The causes of the drought in Mysore and the Madras and Bombay Deccan in 1876, have as yet not been fully ascertained. The snowfall of the winter of 1875–6 was unusually scanty in the North-western Himalayas, although there was a heavy local fall in March and April in a part of the Kashmir Himalayas. The Madras drought and famine was probably due to more general actions and conditions than the winter Himalayan snowfall.

The present meteorological period of abnormal conditions and rainfall it will, however, be seen is not only more prolonged, but is accompanied by much larger variations in the amount and distribution of the rainfall than were experienced in the period of 1876–78. It is, moreover, noteworthy that the cycle or period commenced with excessive rain, continued for a period of three years, and culminating in the year 1893 in an average excess of 9·07 inches, or 22 per cent. of the normal fall. This excess rainfall in India in 1893 was equal to the amount of water necessary to supply its largest canal, the Ganges canal, 300 feet wide, 10 feet deep, for a hundred years. This comparison gives a feeble estimate of the surplus water precipitated over India in 1893, in consequence of the special meteorological conditions and actions of the period.

In order to understand the causes of the partial failure of the crops over at least two-thirds of India in the year 1896, it is necessary to bear in mind the more prominent features of its meteorology, that differ very largely from the meteorological conditions in European countries. The following is a brief statement of the chief features of the two monsoon periods in India.

The year in India may be broadly divided into two seasons or monsoons—viz. the north-east monsoon and the south-west monsoon. These names are derived from the direction of the winds prevailing in the Arabian Sea and Bay of Bengal during the two periods. They are inapplicable over the greater part of India, where the winds are from directions nearly opposite to those indicated by the names of the seasons, and are chiefly determined by the axial directions of the local river valleys. Thus the winds in South Bengal are from south-east, and in Bihar from east, during the south-west monsoon, and are from the opposite directions in the north-east monsoon. It would hence be more appropriate to call the two seasons in India the dry monsoon, and the wet monsoon from their most characteristic features.

The dry monsoon or season usually commences in November or December, and continues until May. Winds of land origin prevail more or less steadily in the interior, and hence the period is usually marked by great dryness of the air and little or no rain. The first three months of this period (December to February), characterised by a comparatively low temperature, are known as the cool weather season; and the second three months (March to May), when the temperature increases rapidly, and culminates in a period of excessive heat in May, as the hot weather season. During the cold weather season, shallow depressions of large extent, the majority of which form in Persia, enter India from Baluchistan and traverse Northern India from west to east, distributing light rain in the Indo-Gangetic plains and heavy snow over the Western Himalayas. The severity of the hot weather season is occasionally relieved by the occurrence of series of thunderstorms and duststorms, which cool the air for brief periods. Over nearly the whole of the interior of India the cold weather and hot weather disturbances occupy a very small portion of the period, and the characteristic features of the dry season are persistent dry weather, with clear skies and large diurnal range of temperature.

The chief crops in Northern and Central India during this period are wheat, barley, linseed, &c., and irrigation either from canals, tanks, or wells is essential in almost all districts for their successful cultivation. If the summer rains cease much earlier than usual, it is not possible to plough and sow the higher and drier lands, and the area of cultivation in the dry season under these conditions is hence largely diminished. If the winter rains are light and scanty, the crops are more or less severely affected on all the higher lands where irrigation from wells, &c., is necessarily limited.

The rains of the wet season set in suddenly on the west coast of India in the first week of June, and a little later (in the second or third week of June) on the Bengal coast, and extend more or less rapidly into the interior. The prevailing winds of this period are of oceanic origin, and are, in fact, the northward extension of the winds of the south-east trades.

The extension of these winds northwards across the Equator and up the Indian Seas usually begins in the third week of May, and gives a complete and permanent change of weather (lasting for five or six months), more especially over the land area of India. The winds due to the extension of these massive humid air currents usually begin to give daily rain to the Malabar coast in the last week of May, and to the Bombay coast on June 4 or 5. The humid currents advance more slowly into the interior, but are usually established before the end of the month over the whole of India. Cloudy, showery, or rainy weather, with a moderately high temperature and small diurnal range of temperature, prevail during the next three months, which are in a striking contrast to the excessively hot and dry weather that has prevailed during the previous two or three months.

The rainfall of India during this period is of the greatest importance, and is sufficient without the aid of irrigation for the crops, except in a few districts (notably Sind and the West Punjab). The rainfall varies considerably in distribution, and slightly in average amount from year to year. The general volume of the current—and hence of the average seasonal rainfall in India—appears to be primarily dependent upon the strength of the currents in the sea areas to the south of India, and hence also of the south-east trades. Consequently it might be expected that any large and persistent variations in the strength of the south-east trades would be reproduced in the strength of the south-west monsoon currents and in the rainfall of the season in India. The local strength of the current in different parts of India varies, to some extent, from year to year, and it has been found that the distribution of the rainfall is largely dependent upon the pressure and other abnormal conditions prevailing in India at the time of its extension, and hence that these can be utilised to forecast the general character of the distribution of the monsoon rainfall. It has been shown, chiefly by Mr. Blanford, that the amount and distribution of the winter snowfall in the Western Himalayas is an important factor in determining these conditions, and hence in modifying the local distribution of the rainfall during the wet or south-west monsoon. Excessive snowfall during the winter proper (*i.e.* December to March), or heavy and unusual snow in April or May, affect the pressure distribution in such a way as to deflect the monsoon currents in their entry into India from one portion of the area (usually North-western India), and determine it more largely than usual to another portion (as, for example, Burma, Bengal or the Peninsula). Under such conditions, one part of the Indian monsoon area receives unusually scanty rain (leading, perhaps, to drought and famine), whilst another area obtains excessive rain. The last notable example of this was in 1891, when Rajputana suffered severely from drought. The winter of 1890–91, in the Western Himalayas, was very severe, and the snowfall excessive and prolonged until May.

It is of the greatest importance to distinguish between the general conditions in the oceanic area (more especially the strength of the south-east trades) affecting the general strength of the monsoon currents prevailing in the Indian monsoon region and the local conditions determining its relative strength in different portions of the Indian land area. For many years—viz. from 1879 to 1891—the local conditions were undoubtedly the predominant factor determining the variation of the south-west monsoon rainfall in India; but the year 1892 introduced conditions and actions, leading to a very large cyclical variation of rainfall, which cannot be explained by local conditions in India, but which appear to be, in part at least, due to variations in the general strength of the south-west monsoon circulation as depending upon corresponding variations in the south-east trades.

The crops during the south-west or wet monsoon may be locally deficient, either from excessive rain and floods or from scanty rains. Partial failure of the crops from excessive rain is usually local in its extension; but the excessive rainfall of the years 1893–94 undoubtedly affected the crops to a serious extent in many parts of the Central Provinces, Central India, and the North-western Provinces, and impoverished the people of these districts to some extent, and hence diminished their capacity to resist the effects of the deficient rainfall and drought in the succeeding years 1895 and 1896.

Deficient rainfall during the wet monsoon is, undoubtedly, the most potent factor in diminishing the staple food crops of India and leading up to food scarcity and famine. The rainfall may be deficient throughout the whole season, as was the case in many districts of the North-western Provinces in the south-west monsoon of 1896; or the rains may cease suddenly and abruptly some weeks earlier than usual, as in the Central Provinces in 1896. In the latter case, prospects may be excellent from the beginning of the monsoon up to the middle or end of September, and then deteriorate rapidly in consequence of the failure of the rainfall necessary for the full growth of the rice and other food crops. This was the case in 1896 over the greater part of the Central Provinces and Bengal, where the partial failure of the rice crop was solely due to the absence of rain in October and November 1896.

The failure of the crops in India, 1896, was more extensive, and spread over a far wider area than has occurred for probably 100 years at least, and its effects were intensified by the four unsatisfactory seasons which preceded it. It was due in a few districts to excessive rain and floods, in a large number of districts to scanty rainfall throughout the whole monsoon, and in others to the early and abrupt termination of the rains from a month to six weeks before the normal date.

The following gives details and data of the more important abnormal features of the south-west monsoon rains of 1896, which were chiefly instrumental in leading up to the very general and partial failure of the summer or wet crops of that year. The table below gives the average or normal date on which the south-west monsoon rains commence in different provinces of India, and the mean date on which they commenced in the same areas in 1896:–

Province	Normal or average date of commencement of south-west monsoon rains	Mean date of beginning of south-west monsoon rains. 1896	Variation from normal date
Bombay (West Coast Districts)	June 5	June 14	9 days later than usual
Central Provinces	,, 10	,, 17	7 ,, ,,
Central India ...	,, 15	,, 21	6 ,, ,,
Rajputana... ...	,, 15	,, 21	6 ,, ,,
Bengal	,, 15	,, 18	3 ,, ,,
Bihar	,, 15	,, 19	4 ,, ,,
North-west Provinces and Oudh	,, 25	,, 21	4 days earlier than usual
East Punjab ...	July 1	,, 25	6 ,, ,,

This table shows clearly that the advent of the monsoon was slightly delayed, more especially in the Arabian Sea and on the west coast of India. The monsoon currents advanced, however, so rapidly into the interior that in Upper India the rains began a few days earlier than usual, establishing that the local conditions in India were favourable. (This was anticipated in the Departmental forecast published in the first week of June antecedent to the arrival of the monsoon, in which it was stated "that the monsoon currents would probably set in on the Bombay coast later than usual, but would advance into the interior more rapidly than usual.")

The monsoon currents held without any general break or interruption throughout the remainder of the month of June, and also during the whole of July and the first three weeks of August, but were less steady than usual. A larger number of cyclonic storms than usual formed in the Bay during this period, as is the rule in a weak monsoon. These storms advanced in the same general direction across a broad belt of country at the head of the Peninsula, stretching from Orissa to Gujarat and Kathiawar. The in-draught to these storms affected the distribution of the rainfall in two respects: it diminished the rainfall in Bengal and the Gangetic Plain, and distributed it more largely and copiously in cyclonic downpours over the areas traversed by these storms, viz. Orissa, the southern districts of Chota Nagpur, the Central Provinces, Berar, the south-western districts of Central India and Rajputana, Gujarat, and Kathiawar.

The following comparative statement indicates roughly but clearly the distribution of the rainfall during this period from the commencement of the rains to the end of August:—

	Province	Rainfall of period June 1 to August 31			
		Average actual (1896)	Average normal	Variation from normal	Percent. variation
		Inches	Inches	Inches	Percent.
Areas of deficient rainfall	Bengal	33·69	44·55	−10·86	−24
	Assam	43·91	54·53	−10·62	−19
	Bihar	25·67	32·88	− 7·21	−22
	North-west Provinces ...	22·42	26·69	− 4·27	−16
	Oudh	22·47	26·33	− 3·86	−15
	Punjab	9·99	12·14	− 2·15	−18
	Rajputana	13·59	16·03	− 2·44	−15
	Central India	28·82	33·28	− 4·46	−13
	Hyderabad, North ...	21·82	22·34	− 0·52	− 2
	Madras Deccan ...	7·62	10·08	− 2·46	−24
Areas of increased or excess rainfall	Orissa	45·62	32·85	+12·77	+39
	Chota Nagpur	42·16	36·31	+ 5·85	+16
	Central Provinces ...	51·19	35·69	+15·50	+43
	Berar	24·28	24·05	+ 0·23	+ 1
	Gujarat	45·00	34·00	+11·00	+32
	Kathiawar	28·51	20·81	+ 7·70	+37
	Bombay Deccan ...	31·60	21·34	+10·26	+48
	Madras East Coast North	20·71	18·71	+ 2·00	+11

The data establish that over the broad belt of country between Orissa and the North Bombay coast, including Orissa, the Central Provinces, the Bombay Deccan, Gujarat, and Kathiawar, the rainfall of the monsoon up to the end of August was in large excess, by amounts averaging from 30 to 50 per cent. It was, on the other hand, in defect by nearly equal percentage amounts over the whole of India to the north of that belt, *i.e.*, in Bengal, Bihar, the North-western Provinces, Central India, Rajputana, and the Punjab. It is assumed in the rainfall maps prepared weekly for the Government of India that a seasonal deficiency in a meteorological district or province of 20 per cent. or upwards is large, and that the crops in such an area will be seriously affected unless the rainfall is very favourably distributed throughout the whole season. The data hence show that the rainfall during the period June to August 1896 in Bengal, Bihar, and the Madras Deccan was in serious deficiency, and that it was also in marked defect in the provinces of Assam, the North-western Provinces, the Punjab, Central India (east), and Rajputana, by amounts verging on what may be termed the danger line. It should, however, be noted that, although the rains over the greater part of Northern India were scanty; they had been on the whole favourably distributed (more especially in Bihar and Bengal), and the chief food crops in these districts only required moderate and seasonable rain during the next six or eight weeks in order to give a fair to satisfactory outturn. The rice crop in Bihar, the eastern districts of the North-western Provinces, the Central Provinces, and Bengal especially, requires fair rain in September to complete its growth. Unfortunately, the rains at this critical period, in September 1896, failed almost entirely in Northern and Central India in consequence of the abnormally early retreat of the humid monsoon currents and the prevalence of dry, clear, and much warmer weather than usual in September and October, at a time when occasional rain is essential.

The monsoon currents withdrew from the whole of Northern and Central India from four to seven weeks earlier than usual, in August and September 1896, as shown in the following table. The conditions and features of the withdrawal and retreat of the current were practically normal in all other respects. The table gives data showing the very early termination of the rains.

Province	Normal or average date of termination of south-west monsoon rains	Mean date of termination of south-west monsoon rains, 1896	Monsoon closed earlier than usual by
East Punjab ...	September 15	August 22	24 days
North-Western Provinces and Oudh ...	,, 30	,, 30	31 ,,
Bihar	October 15	September 18	27 ,,
Bengal	,, 31	,, 21	40 ,,
Rajputana ...	September 20	August 18	33 ,,
Central India ...	,, 30	,, 28	33 ,,
Central Provinces	October 15	,, 31	45 ,,
Bombay ...	,, 15	,, 31	45 ,,

The preceding data establish that the monsoon rains ceased from three to six weeks earlier than usual, and also that this acceleration was greatest in the rice-growing districts of Bengal, the Central Provinces and Bombay, where it was most prejudicial in its effect on the staple crops.

The general failure of the rains in September and October 1896, is shown most fully by the data of the following table:—

Province	September 1896		October 1896	
	Variation of rainfall of month from the normal	Percentage variation of rainfall of month from the normal	Variation of rainfall of month from the normal	Percentage variation of rainfall of month from the normal
	Inches		Inches	
Assam	−0·23	−2	−3·16	−65
Bengal	+0·85	+8	−3·94	−87
Bihar	−2·38	−28	−2·66	−99
Chota Nagpur	−3·43	−41	−2·92	−100
North-western Provinces	−5·82	−91	−1·47	−99
Oudh	−6·55	−95	−1·59	−99
Punjab	−2·04	−78	−0·22	−65
Berar	−5·85	−94	−2·29	−99
Central Provinces ...	−6·45	−79	−1·98	−100
Central India	−6·12	−93	−1·66	−100
Rajputana	−2·17	−87	−0·26	−89
Gujarat	−6·28	−78	−1·36	−100
Kathiawar	−4·19	−89	−0·69	−100
Bombay Deccan ...	−4·33	−78	−4·19	−84
Madras, Central ...	−2·98	−56	−4·85	−93
,, East Coast North	−1·97	−28	−6·96	−98
Hyderabad, North ...	−5·74	−76	−2·43	−89

The preceding data show clearly the very serious deficiency of rain in September and October. Thus in the month of September, the rainfall over the whole of India north of lat. 12°, with the exception of Assam, Bengal, Bihar, Chota Nagpur and North Madras, was only one-seventh or 14 per cent. of the normal amount, and in the month of October the rainfall over the whole of India north of lat. 14° was less than one-twelfth of the normal, and over the greater part of the area, including Bihar, Chota Nagpur, North-western Provinces, Oudh, Berar, the Central Provinces, Central and North Madras, Gujarat and Kathiawar, the rainfall of the month was practically or absolutely *nil.*

It will thus be seen that in the large area including Bengal, Bihar, the North-western Provinces, Punjab, Rajputana, Central India (east), the wet or south-west, monsoon crops (usually called the kharif) failed to a more or less serious extent: (1) from deficient rainfall throughout the season; (2) from the abnormally early and abrupt termination of the monsoon rainfall three to seven weeks earlier than usual. In another large area including Berar, the Central Provinces, and the greater part of the Deccan and North Madras, although the rainfall during the first three months of the monsoon was more abundant than usual, the early termination of the monsoon, about six weeks earlier than usual, affected the crops almost as seriously as in the first area, including the greater part of Northern and Central India.

The preceding discussion has shown the chief features of the south-west monsoon of 1896, which made it so disastrous a season for the staple food crops in India.

It is natural to inquire whether the deficiency of rainfall in India accompanied a greater determination of the monsoon currents towards, and hence heavier rainfall in, the remaining land areas of the monsoon region.

The chief land areas which obtain, in general, moderate to heavy rains from the south-west monsoon winds (the continuation of the south-east trades of the Indian Seas) are: (1) India; (2) Burma, Siam and the Malay Peninsula; (3) the equatorial lake region of Central and East Africa and the Abyssinian highlands.

In nine years out of ten, when the rainfall is in marked defect in Northern India, it is more or less in excess in Burma; and the monsoon of 1896 was no exception to the rule, as is shown by the following:—

Division	Rainfall from May 31 to October 17, 1896			
	Average actual	Average normal	Variation from normal	Percentage variation
	Inches	Inches	Inches	
Tenasserim	183·86	154·58	+29·28	+19
Lower Burma (Deltaic).	106·59	81·57	+25·02	+31
Arakan	161·74	156·86	+ 4·88	+3

The very limited information I have received indicates that the precipitation was also in excess in Siam.

Information of the rainfall in the third region of summer monsoon rainfall has not yet reached India. I am, however, informed that the curve showing the flood level of the Nile at the gauge stations at Assuan and at the Barrage, near Cairo, at the head of the Delta, for the past year was most unusual. Instead of having one maximum in September, as is usually the case, it presented two well-marked maxima, the first being the ordinary and absolute maximum in September, and the second an abnormal and secondary maximum in November, apparently due to heavy rainfall in October in Abyssinia. Heavy rain is reported to have fallen in the Upper or White Nile Basin in November. The defection of the humid current indicated by this fact is confirmed by the unusual and abnormal easting of the winds in October and November at the Seychelles and Zanzibar. This heavy rainfall hence occurred in the African region at the time when the retreating south-west monsoon was giving unusually scanty rain in Southern India and the Deccan.

It is also probable that the rainfall in the sea area passed over by the monsoon currents in their advance towards India may have been greater than usual. Mr. Blanford, in his monograph on the rainfall of India, has laid down the following principle: "that it is not when the monsoon current is blowing steadily that rain is most probable, but when it is defected from its normal direction by some local irregularity of pressure."

It is not possible at the present time to obtain direct evidence on this point. The rainfall of the Seychelles and Zanzibar during the period June to September of the past five years has, on the whole, varied inversely to that of the same period in India, thus slightly in favour of the assumption that the rainfall in the sea area was somewhat larger than usual during the past two years, and more especially in 1895.

So far as can be judged from the limited data available, it is almost certain that the distribution of the rainfall in the whole monsoon land region has not been compensatory, and hence that the precipitation has, from some unknown conditions or actions, been below the normal to a considerable extent, probably more than 5 per cent. of the average of the whole area. It is not possible to infer whether this deficiency has been compensated by a heavier precipitation over the equatorial belt of the Indian Ocean and over the Arabian Sea and Bay of Bengal. The data for the insular stations of Port Blair, Minicoy, Amini Devi and the Seychelles are certainly opposed to this supposition.

It is hence almost certain that the deficient rainfall in India in the past year, 1896, is only a phase of conditions and actions extending over a much larger area.

The variations in the amount and distribution of rainfall in India during the past five years, 1892–6, cannot be explained by the local meteorological conditions, either antecedent to or during the monsoon, and are, in fact, of such a character as to indicate that they are probably mainly due to corresponding variations in the strength of the south-east trades, of which the south-west monsoon circulation is the northward extension from June to October. As the strength of a steady horizontal air movement is directly related to the pressure gradients, the variations of the latter, which are approximately known from the pressure data of the Observatories at Mauritius, Zanzibar, the Seychelles, and Colombo, may be employed to indicate roughly the variations in the strength of the south-east trades from 1892–6.

The following gives the mean differences of pressure between Mauritius and Zanzibar, Seychelles and Colombo (1) for the period June to August, and (2) for the period June to October of each year from 1891 to 1896:—

Year	Mean pressure difference of period June to August		
	Mauritius to		
	Colombo	Zanzibar	Seychelles (observatory opened 1894 April)
	"	"	"
1891	·321	·071	
1892	·339	·087	
1893	·377	·104	
1894	·335	·078	·221
1895	·334	·065	·215
1896	·350	·099	·236
Normal difference...	·335	·080	·230

Year	Mean pressure difference of period June to October		
	Colombo	Zanzibar	Seychelles
	"	"	"
1891	·312	·091	
1892	·324	·102	
1893	·339	·116	
1894	·305	·090	·205
1895	·308	·075	·201
1896	·319	·105	·220
Normal difference...	·310	·095	·210

The preceding data establish conclusively that the mean pressure differences or gradients in the south-east trades region during the south-west monsoon periods of the past five years, 1892–96, exhibit a similar law of variation to that of the rainfall of India. The gradients or pressure differences were above the normal in 1892, 1893, and 1894, reaching their maximum normal in 1893, and considerably below their mean value in 1895. The figures seem to indicate that the maximum and minimum pressure effect precede by some months the maximum and minimum rainfall in India, a very important indication if further experience should show it is a general rule and not a casual coincidence.

The variations of gradient almost certainly indicate corresponding variations in the strength of the south-east trades. That there are variations in the strength of the south-east trades has been suggested by Mr. W. E. Hutchins, Conservator of Forests to the Cape Government, in explanation of the variations of rainfall from year to year in the Cape Colony. In a letter (written in April 1896), which I received from him in June, and sent for publication to several of the Indian newspapers, he says: "The absence of the south-east trades in the Cape throughout the past summer (*i.e.* November 1895 to March or April 1896) has brought abnormal summer rains to the Cape Peninsula, and drought, scarcity and locusts to the bulk of the continent, where the usual summer rains have failed. Are the south-east trades at present deficient in energy? The south-west monsoon in India is held to be an extension of the south-east trades. After what has happened in South Africa it will be interesting to note the character of the coming monsoon in India. There are two indications pointing to the failure of the coming Indian monsoon (in 1896).

"(1) The failure of the south-east rains in South Africa.

"(2) The cyclical variation of weather in South Africa."

Mr. Hutchins' anticipations were unfortunately fully verified, and confirm the probability of the relation between the varying strength of the south-east trades and the monsoon rainfall of India.

I have recently had my attention called, by Captain Froud, Secretary to the Shipmasters' Society, to the presence in large numbers of icebergs in the Antarctic Ocean, much further north than usual, off the Cape Colony coast, to such an extent, in fact, as to be dangerous to steamers following the "safety track" from London to New Zealand, adopted by several English steamer lines. One vessel met with icebergs as far north as lat. 35° N., and numbers, said to be from 400 to 600 feet above water, have been encountered by steamers during the past eighteen months, at least, in lat. 42° to 45° S., to the south, south-east and south-west of the Cape. The following give extracts from the log of the s.s. *Thermopylæ*:—

1896.		Lat. S.	Long. E.	
September	22	45°	49°	Passed iceberg ½ mile long and 640 feet high.
,,	23	—	—	Very large icebergs, with perpendicular sides and flat top, ¾ mile long and 400 feet high.
,,	24	—	—	Passed two large icebergs and many small pieces.
,,	25	46°	70°	Several large icebergs seen.
,,	26	46½°	75°	Last iceberg seen.

The captain adds that measurements were carefully taken by the sextant when the icebergs were suitably situated near the track of the vessel.

The captain of the s.s. *Port Melbourn*, in a letter dated London, February 11, 1897, writes: "On our passage out last voyage to Albany (Western Australia), we encountered a number of large icebergs (about forty-five in all) and a quantity of smaller pieces of ice between lat. 44° S. and 45° S. and long. 49° E. and 70° E. The larger icebergs ranged from ½ mile to 2 miles in length and from 300 feet to 820 feet in height (as measured by the sextant). It is very evident that ice in the Southern Indian Ocean now appears to work its way further north than formerly, thereby increasing the risk of the southern passage to Australia."

Mr. Allingham, of the English Meteorological Office, has kindly supplied me with a summary, tabulated below, of the data he has collected, indicating the abnormal number and northward extension of icebergs in the south-east of the Indian Ocean during the past two years.

The following summarises the chief features of the remarkable cyclonic variation of rainfall in India during the past five years, and which culminated in partial failure of the crops and scarcity over so wide an area in 1896:—

Year	Rainfall			
	Mean actual	Mean normal	Variation from normal	Percentage variation
1892	46·18	41·09	+ 5·09	+ 12
1893	50·16	41·09	+ 9·07	+ 22
1894	47·56	41·09	+ 6·47	+ 16
1895	38·90	41·09	− 2·19	− 7
1896	36·26	41·09	− 4·83	− 12

If single stations, in the province most largely affected by the abnormal condition of the period, were selected, the contrast between the excess in the years 1892–94 and the deficiency of the years 1895–96 is very marked. The table at the top of p. 115 gives data of total rainfall of period June to October at one station in the Central Provinces, one in the North-western Provinces, and one in Bihar, in illustration of this.

At Allahabad, the headquarters of the Government of the North-western Provinces, the area most seriously affected, the total rainfall in 1894 was practically double the normal, and in 1896 barely half of the normal.

Ship		Date	Position	Number of icebergs seen	Remarks
s.s. *Thermopylæ*	...	June 24, 1895	45° S. 49° E.	12	Some 400 feet high
Armida ...	...	July 9, 1895	42 S. 43 E.	1	400 feet high
s.s. *Zainui* ...	...	July 10, 1895, to July 13, 1895	44 S. 45 E. to 45 S. 67 E.	13	100 feet to 200 high
Gainsborough	...	July 15, 1895, to July 17, 1895	42 S. 43 E. to 42 S. 51 E.	5	
s.s. *Port Chalmers*	...	July 27, 1895	45 S. 52 E.		Steamer collided with an iceberg
Queen Mab	...	Aug. 6, 1895	35 30′ S. 20 45′ E.	7	70 feet to 200 feet high
s.s. *Kaikoura* ...	...	Nov. 17, 1895	45 S. 52 E.	1	Very large
s.s. *Gulf of Lions*	...	Dec. 23, 1895	47 S. 50 E.	1	130 feet high
s.s. *Buteshire* ...	...	Aug. 5, 1896, to Aug. 7, 1896	45 S. 55 E. to 46 S. 66 E.		Several, mud loose in
s.s. *Thermopylæ*	...	Sept. 22, 1896, to Sept. 25, 1896	45 S. 50 E. to 46 S. 71 E.	30	300 feet to 640 feet high (640 feet by sextant)
s.s. *Tongariro* ...	...	Oct. 1896	45 S. 50 E. to 47 S. 80 E.	200	Some very large
Loch Fergus	...	Oct. 13, 1896, to Oct. 20, 1896	45 S. 50 E. to 46 S. 78 E.		Numerous icebergs
Firth of Lorn	...	Oct. 27, 1896	43 S. 57 E. to 43 S. 59 E.	3	300 feet high
s.s. *Otarama* ...	...	Nov. 3, 1896, to Nov. 7, 1896	46 S. 54 E. to 47 S. 77 E.	336	Mud small
s.s. *Stassfurt* ...	...	Nov. 29, 1896, to Dec. 1, 1896	44 S. 68 E. to 45 S. 79 E.	3	50 feet, 70 feet, 250 high
s.s. *Matatua* ...	...	Nov. 9, 1896, to Nov. 14, 1896	45 S. 52 E. to 46 S. 81 E.	57	One 420 feet high
s.s. *Pakeha* ...	...	Dec. 3, 1896, to Dec. 10, 1896	45 S. 50 E. to 45 S. 80 E.		Very many

The data hence show that there was a strongly marked cyclical variation of the rainfall of India in this period, the maximum of which was 1893, and the minimum (probably) in 1896. In the year of maximum rainfall (1893), the south-west monsoon commenced early and withdrew much later than usual, and gave excessive rain throughout the whole period of its prevalence, whilst that of 1896, the year of minimum rainfall, commenced late, withdrew early, and gave scanty and very deficient rain throughout the whole period. The marked contrast between the two years was, it may be noted, not restricted to the south-west monsoon. In 1893 and 1894 the rainfall was above the normal in each of the four seasons into

Station	Normal rainfall in use previous to 1894	Normal rainfall in use since 1894	1892		1893		1894		1895		1896	
			Mean actual	Variation from normal	Mean actual	Variation from normal	Mean actual	Variation from normal	Mean actual	Variation from normal	Mean actual	Variation from normal
Suegor	41·03	45·67	47·21	+ 6·18	61·50	+ 20·47	69·96	+ 24·29	42·16	− 3·51	37·13	− 8·54
Allahabad	33·43	37·00	32·92	− 0·51	45·94	+ 12·51	69·60	+ 32·60	25·94	− 11·06	19·93	− 17·07
Motihari	42·52	47·60	65·16	+ 22·64	79·31	+ 36·79	43·12	+ 0·60	57·29	+ 14·77	28·84	− 18·76

which the year is divided in India, whereas from March 1895 to March 1896 it was more or less in defect in each season, as is shown by the data of the following table.

The variations in this table are calculated from the data of over 2000 stations for which normal monthly means have been calculated, and no allowance is made for the area represented by each station. The total annual variation hence varies considerably according to the two methods of calculation, but it will be seen that they agree in the general character of the cyclical variation :—

Year	Rainfall variation of whole of India (excluding Burma)				
	January and February	March to May	June to Sept.	November and December	Of whole year
	Inches	Inches	Inches	Inch	
1892	−0·37	+0·42	+4·39	−0·96	+3·48
1893	+1·42	+3·62	+3·39	+0·49	+8·82
1894	+0·53	−0·10	+7·56	+0·31	+8·30
1895	+0·04	−0·08	−3·27	−0·72	−4·03
1896	−0·45	−1·09	−3·80	+0·33	−5·01

The main features of the rainfall during this period were hence not special to the south-west monsoon, but general and affecting the meteorology of the whole year. This fact indicates that the causes of the periodic variations are not only general, but due to more or less permanent and persistent meteorological conditions or actions affecting the meteorology of the whole period over a considerable portion of the earth's surface.

It has apparently been established in the discussion that the variations of the rainfall in India during the past six years are parallel with and in part, at least, due to variations in the gradients, and the strength of the winds in the south-east trade regions of the Indian Ocean. The discussion has indicated that there are variations from year to year in the strength of the atmospheric circulation obtaining over the large area of Southern Asia and the Indian Ocean, and that these variations are an important and large factor in determining the periodic variations in the rainfall of the whole area dependent on that circulation, and more especially in India. It has also been indicated that these variations which accompany, and are probably the result in part of abnormal temperature (and hence pressure), conditions in the Indian Ocean and Indian monsoon area may be in part due to conditions in the Antarctic Ocean, which also determine the comparative prevalence or absence of icebergs in the northern portions of the Antarctic Ocean.

The economic effects of these very large variations of rainfall during the past five years has been very great, almost disastrous, in India. The variations are so large in amount, and affect so vast an area, as to suggest that meteorological science should have no difficulty in assigning the causes or chain of actions leading up to these effects. Facts have been given in the present paper which suggest an explanation, but it is doubtful whether it can be regarded as satisfactory.

There appear to be only two explanations possible of this periodicity. The first is that it represents large cumulative effects of opposite phases in different parts of the earth. So far as the whole Indian monsoon area is concerned, the variations in different parts have not been compensatory ; and the rainfall in 1896 has almost certainly been below the normal, on the mean of the whole area. It would be an interesting study for a Central International Weather Bureau to investigate. So far as can be judged from a brief examination of the weather reports of other countries, there appear to have been no large and marked periodic variation in other parts of the world corresponding to the variation in India—of either the same or opposite phase. It is hence, on the whole, probable that the periodic rainfall variation of the past five years in India has not been compensated by a similar variation of opposite phases elsewhere. If it were the case, it would be purely a question of meteorological investigation.

The second explanation is that this periodic variation of rainfall in the Indian Ocean during the past five years may be one phase of general actions in the earth's atmosphere, due to abnormal variations in the radiation and absorption of solar energy, and hence to some abnormal phase of the sunspot periodicity. Perhaps the observations recorded at Solar Physics Observatories during the past five years may throw light on the question ; and if such be the result, it would furnish a powerful argument for India assisting in the work of Solar Observatories to a much larger extent than she has hitherto done.

The question which now affects India most seriously is, whether the rainfall of the present monsoon is likely to be seriously in defect.

An examination of the figures certainly indicates a probability that the mean rainfall of the year will be below the normal. If the causes of the variations were known with certainty, it would probably decide the question.

J. E.

THE INSTITUTION OF CIVIL ENGINEERS.

ON Tuesday, Wednesday, and Thursday of last week, May 25, 26, and 27, the Institution of Civil Engineers held a conference. This is a thing unprecedented in the annals of the Institution, it having confined itself hitherto to weekly meetings during the London season. Not only were there daily sittings, many of them proceeding simultaneously, for the reading and discussion of several papers, but there were also excursions to works and "other objects of interest." There was, as well, a conversazione ; but this is no novelty for the Institution. A very large number of members attended the meetings, the Westminster Town Hall and the Westminster Guildhall having been retained for the purpose. The general plan of the conference was for one or more members to read a short note by way of initiating a discussion. As there were nearly fifty items in the programme, the congress being divided up into seven sections, it will be evident that in the small space at our disposal we cannot even refer to all the subjects brought forward.

Proceedings commenced at half-past ten on Tuesday, May 25, by the President reading a short address in the Westminster Town Hall, in which the scope of the conference was sketched out. The members then dispersed to the different sections. Section I. was devoted to railways, and the proceedings commenced by Mr. Harold Copperthwaite reading a note on rails and permanent way. He was followed by Mr. F. W. Webb, of Crewe, who read a note on the same subject. The discussion was of an entirely practical and professional nature. Mr. Webb introduced a model of a joint chair ; that is to say, a device which combined in itself a rail chair and fishplate. It will be a great boon to railway travellers if this apparatus can be introduced, supposing it will fulfil all the promises made on its behalf by its originator, for there is no doubt that a very great part of the jar and rattle of railway travelling is due to the giving of rails at the joints. This fact was illustrated by means of lead fishplates, which Mr. Webb had used for the purpose of showing what was the amount of deflection at rail connections ; it was considerable. The joint chair referred to is of massive construction, and care will have to be taken that too much progress is not made in the direction of rigidity, otherwise there will be repeated the old trouble experienced with stone blocks for sleepers ; some flexibility is needful for a good road. In